HCTL Open International Journal of Technology Innovations and Research (IJTIR)
http://ijtir.hctl.org
Volume 20, Issue 1, May 2016
e-ISSN: 2321-1814, ISBN (Print): 978-81-932623-0-6

Design and Implementation of a Gantry Robot for Pick and Place Mechanism with Obstacle Detection using Programmable Logic Controller

Shubhi Thatere[1], Parbbhpreet Arora[1], Yajush Sharma[1], Roushan Kumar[2], Raj Gaurav Mishra[2]

shubhithatere@gmail.com

Abstract

The Project presents the design and implementation of a gantry robot, which performs pick and place mechanism and also detect the obstacles coming in its path. Picking and placing manually is the inefficient flaws for the production line industries. It become less productive, slow and non flexible processing when it comes to manual mechanism. To overcome this problem we introduce a 3 axis rectangular plane gantry robot. This is a Cartesian coordinate robot, which performs pick and place mechanism and also detects the obstacles which encounters in its path. The system comprises of gantry robot with a conveyor system, and completely controlled by programmable logical controller. This provides the effective design of the system. The most important requirement to take into account were those regarding accuracy, weight of the object, metal and non metal detection, obstacle detection and overall cost of the system.

Keywords

Cartesian robot, Programmable Logic controller, Proximity sensor, Pneumatic cylinder

[1]Students, CoES, University of Petroleum and Energy Studies, Dehradun, India.
[2]Faculty Members, CoES, University of Petroleum and Energy Studies, Dehradun, India.

Introduction

The development of manipulation system for different application purposes has been carried out at the department of electronics control and instrumentation of the University of Petroleum and energy studies. The system indented for the most general application scope ranging from industrial application to more specific application such as medical tasks. For the accurate analysis, the Cartesian coordinate robot has been chosen with 3 degree of freedom, working in X ,Y and Z axis .Due to the need of a modular structure so that, the components of the robot can be easily substituted and removed without disturbing the whole structure. For instance in this system, we have added an end-effecter in Z axis which is now a vacuum cup for pick and place mechanism that can be replaced easily with some different actuator according to the requirement .In any case the supportive structure should be cost effective and easy to control which led to the choice of a gantry robot. The project is described in various sections like controlling and monitoring through PLC, motion of three axis through DC motors, Ladder logics in Indra logic software for working with Rexroth PLC, Circuit Designing in a supportive system (3DOF robot), conveyor system and sensor arrangements. Programmable logic controller (PLC) also known as programmable controller is a digital computer. The automation of typically industrial electromechanical processes such as control of assembly lines, amusement rides or light fixture is controlled through these controllers. PLC's are designed for multiple arrangements of digital and analog inputs and outputs. PLC's are immune to electrical noise and also resistant to vibration and impact. The non-volatile memory stores the program of PLC's used for controlling machine operation. Human machine interface is a platform which allows the interaction between automation equipments and users. It allows effective operations and control of machines from the human end, while the machine simultaneously feeds back information that aids the operators' decision-making process.

The advantage of this pick and place gantry robot are its capabilities to move in X, Y and Z direction. It rigidly allows for more precision. It is easy to program and is strong dependable mover. Its payload is larger and fully supported. The main goal of this paper is the implementation of a pick and place mechanism gantry robot which can detect the obstacle which comes in their path and stops the complete system in such situation. This is evaluated using the base gantry system, conveyor system, sensors, HMI and the PLC.The paper is organized as follows. I section describes introduction about gantry robot, II section completes the system hardware designing, III section is the Software Design, IV section Ladder logic Programming and V concludes the paper with results and discussion of the system with conclusion.

System Hardware Design

The design of Pick and place gantry robot is divided into 3 parts

Gantry Robot Base Structure

For this project, the base structure used is iron stand of 70cm x 50cm dimensions representing X and Y axis of robot with the threaded rod which works as a rail for the movement of the end effector in X and Y directions as shown in the figure below. The motions from one position to another are taking place using DC motor of 12 Volts which

is carried out using relays to interface motors with PLCs which works on 24 volts. The geared Dc motor used in X and Y axis works on 200 RPM, Torque of 2 kgcm and a current of 3.2 Amps and 2.8 Amps. On the Z axis, the end effectors is connected which is a pneumatic air cylinder with a vacuum cup. The end effector is tied up with a proximity sensor which senses the obstacle and will stop the complete system.

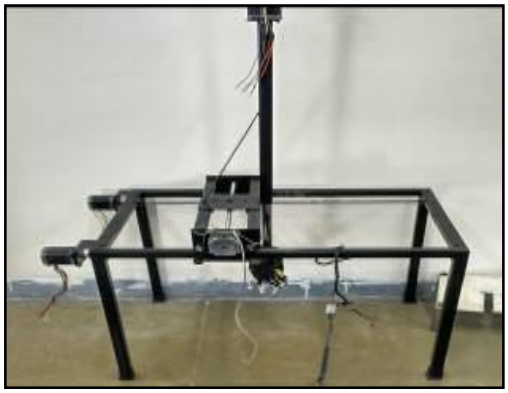
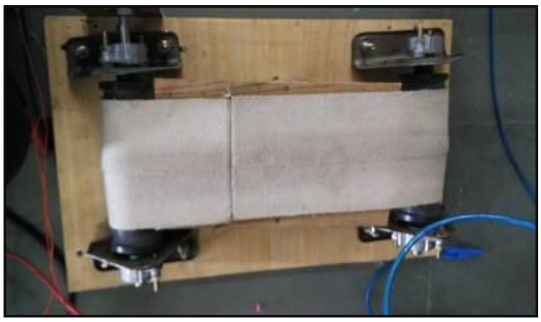


Figure 1: Base structure of a gantry robot

Conveyor System

The conveyor system is basically to place metal and non metal object from where the end effector will pick the metal which will be detected through the proximity sensor fixed to one end of the conveyor. The proximity sensor of Rexroth is been used with Voltage between 10-30 Volts and current of 400 mA with a range of 5mm. The system is driven by a 12V geared DC motor of 200 rpm, torque of 2 Kg cm and current of 3.4 amperes.



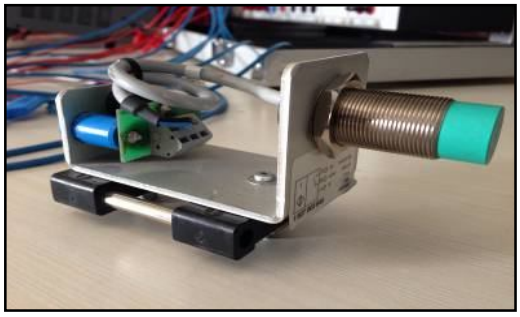


Figure 2: Conveyor system and the Proximity sensor

PLC and Hardware Interfacing

For this system, the Rexroth PLC is been used. It has input/output modules for initializing different I/Os with specific addresses, there are relay modules, Push buttons and hoses (wires used in PLCs). For PLC and the robot interfacing the major role is played by the directional control valves which help the air cylinder and vacuum cup to work. Speed control valves, vacuum ejector distributers, connectors are some other pneumatic components used to complete the circuitry. Here we have used two 4/3 directional control valves, one for the air cylinder actuation and other for suction mechanism of the vacuum cup. This can be understood more clearly through the images given below.

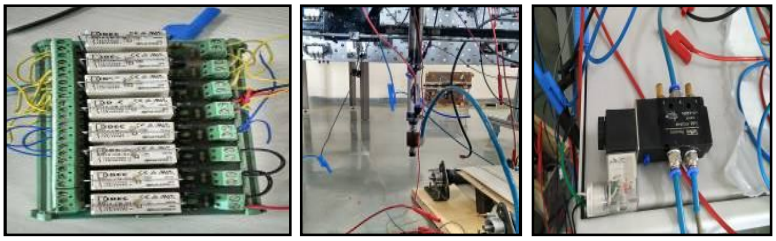


Figure 3: Relay arrangement, air cylinder with vacuum cup & 4/3 directional control valve

Figure 4: Proximity sensor for obstacle detection and PLC-robot interfacing

System Software Design

The Many challenges exists for designing a gantry robot with the increasing requirements on quality of product and its life, the automation industry has done an exponential development and the electrical control of the robot into a new period of development. The control is done by the programmable logic controller (PLC) instead of the original relay logic control, and microcontroller based control.

Visualization and HMI

HMI is a human machine interface which provides a link between the inputs and the PLC and can be used as the indicator. In this research paper we used the HMI for the lift box internal switch panel as well as it is also used to indicate the current floor and status of pressed button, along with this emergency button is provided to vacate and stop the system at the time of emergency situation Visualization in Indraworks engineering is almost similar to that of SCADA. Visualization is generally used to create a GUI (Graphical User Interface) to provide an ease hand on working on the application and supervision of the project and automation unit. In this system visualization we designed Master reset, inside calling buttons, outside calling buttons, proximity status buttons and the motor status light to indicate proper working and checking the fault in the system. With help of VCP HMI software, visualization is done which is shown in images.

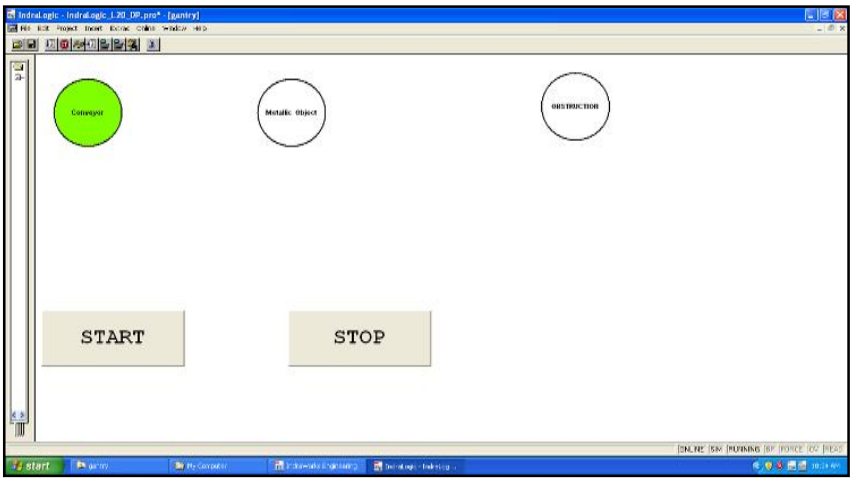


Figure 5: HMI Screen

In this project the HMI interface is created on INDRA WORKS using visualization tool. The HMI as of now consist of 2 buttons (start and stop) and 3 indicators (conveyor, metallic object and obstruction). The buttons as their name suggests are used to switch on and switch off the working of the gantry but an emergency stop is also included manually.

Flow Chart of the System

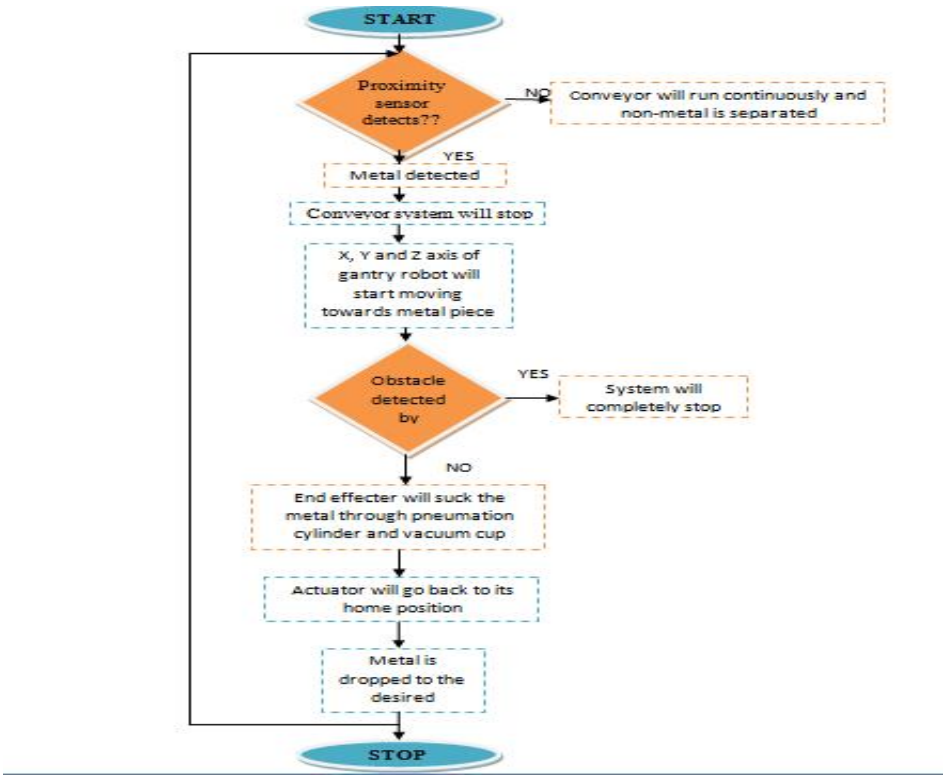
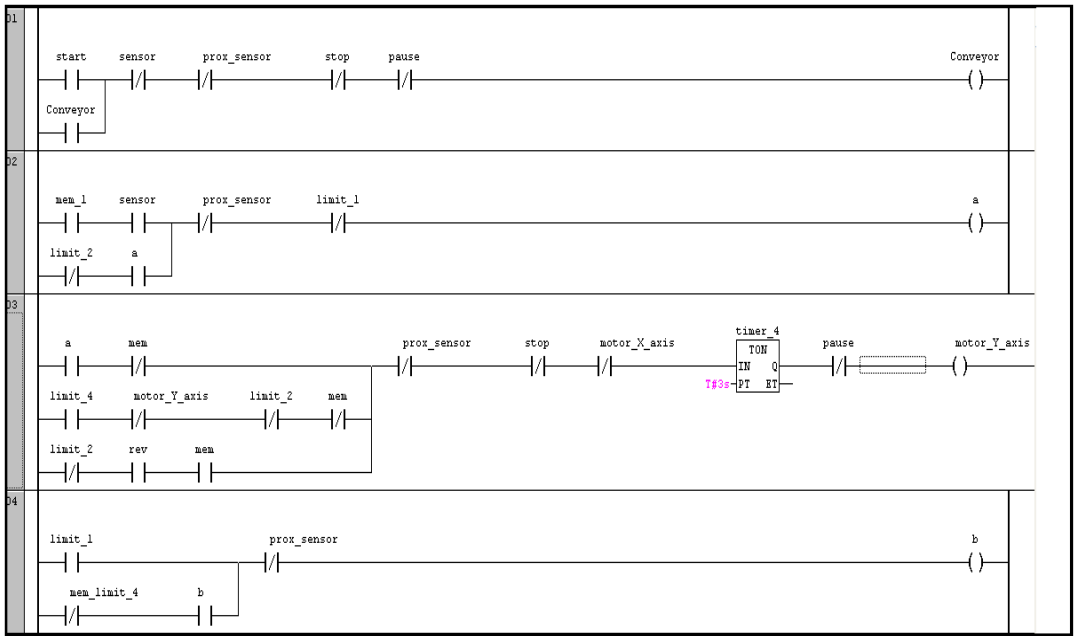
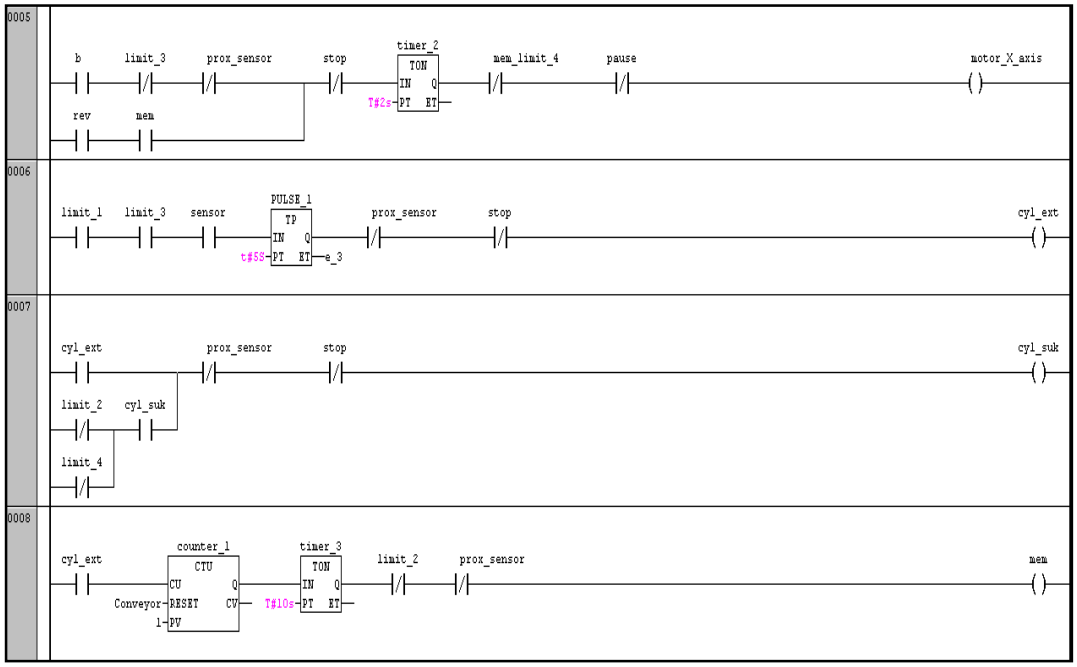


Figure 6: flow chart

HCTL Open International Journal of Technology Innovations and Research (IJTIR)
http://ijtir.hctl.org
Volume 20, Issue 1, May 2016
e-ISSN: 2321-1814, ISBN (Print): 978-81-932623-0-6

Ladder Logic Programming





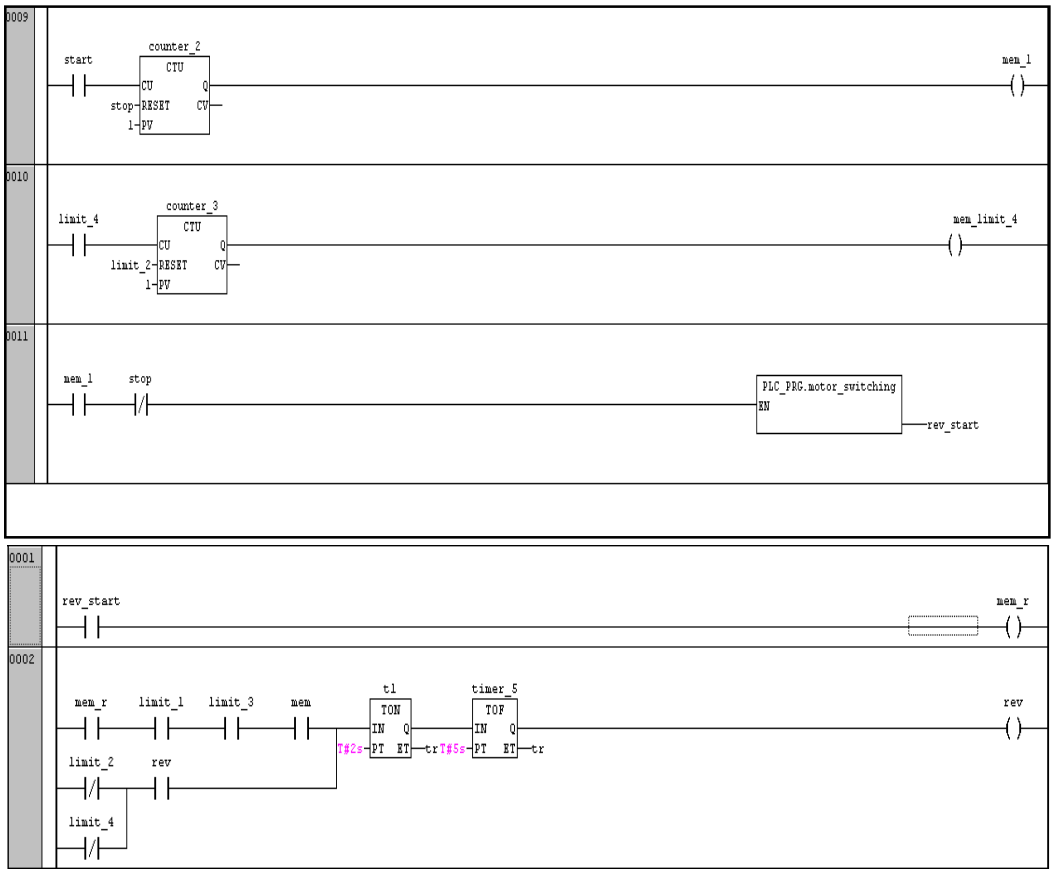


Figure 7: SCREEN 1, 2, 3 & 4

Results and Discussion

The experimental setup of a gantry robot for pick and place mechanism and obstacle detection is shown in the figure given below, which consists of the base gantry robot with its three axis, a conveyor system, Rexroth PLC setup, SMPS and its interfacing with DC motors for its controlling and Indraworks for programming.

CASE-1: when the metal is detected in the conveyor system, through proximity sensor, the conveyor system will stop and the three axes will start moving forward. After it reaches to the end position the metal is sucked through pneumatic vacuum system and finally drops it to the desired location.

CASE-2: when the obstacle is detected by the sensor in its path, the complete system will stop and no further processing can take place.

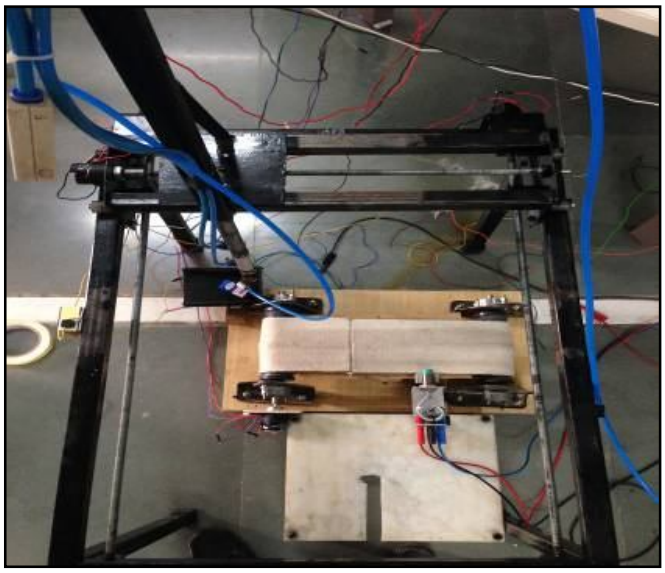


Figure 8: Complete Setup of a Gantry Robot System for Pick and Place Mechanism and Obstacle Detection

Conclusion

With design and development of a gantry robot with help of REXROTH L20 PLC the safety, good ergonomics and noise reduction of the Pick and place system can be increased to larger extent. As infrastructural growth are increasing day by day so there is a need of efficient and cost effective industrial automation system, which can deliver reliable, stable and constant speed which is easily achieved with proposed system. The design in both mechanical components and control software should confirm to the principles of safety system. This paper introduces some measures to improve the safety of the pick and place system, which contributes to the stable operation of monitoring system field section PLC and ensures the communication between system and server machine. With the more and more application of new technology, we believe the gantry robot safety system will be more and more perfect. There is a lot of work is to be done in the field of industrial automation. Smart detection techniques and equipment concept can be incorporated for the improvement of the system like safety systems, Control mechanism etc. In our system work in the field of safety and control in ambiguity situation is required.

References

[1] Design and implementation of a Cartesian robot, Published in Advanced manufacturing systems and technology CISM courses and lecture number 437, Springer Wein New York 2002.

[2] Ali Ahmad El Souki, 2D Pick and Place robot, The Lebanese University Thesis, June 17, 2013.

[3] Pablo Sánchez-Sánchez; Fernando Reyes-Cortés, Cartesian Control for Robot Manipulators, Manipulators Trends and Development, Agustin Jimenez and Basil M Al Hadithi (Ed.), ISBN: 978-953-307-073-5

[4] S. Krishankant, Computer Based instrumentation Control, New Delhi: PHI Learning Pvt. Ltd, 2009.

[5] Ma Yinyuan; Jiang Zhaoyuan, Task-Oriented Analysis and Design Method for Developing PLC Programs for Mechanical System Control, International Conference on Measuring Technology and Mechatronics Automation, IEEE Conference Publications, vol. 3, pp 726-729, 2010.

[6] Reiner Dudziak, Dirk Mohr, Development Projects as an Integral Element Education of Mechatronics Engineers, IEEE Mechatronics-REM, 2012.

[7] P.H Meckl; W.P Seering, Experimental Evaluation of Shaped Inputs to Reduce Vibration for a Cartesian Robot, Journal of Dynamic System, Measurement, and control,volume112, doi:10.1115/1.2896122.

[8] Pattacini, U, Nori, F, Natale, L, An Experimental evaluation of a novel minimum-jerk Cartesian controller for Humanoid robots, Intelligent Robots and Systems (IROS), 2010 IEEE/RSJ International Conference on 18-22 oct. 2010.

[9] Wilson, William J, Relative end effector control using Cartesian position based visual serving, Robotics and Automation, IEEE Transactions on (Volume: 12, Issue: 5).

[10] Mohsen Dadfarnia, Nader Jalili, and Darren M. Dawson, An Observer-based piezoelectric control of flexible Cartesian robot arms: theory and experiment, Control Engineering Practice, August 2004, Vol.12 (8):1041-1053.

[11] C. Blume; W. Jakob Programming Languages for Industrial Robots, 1986: Springer-Verlag.

[12] J. L. Nevins, Adaptive control, learning and cost effective sensor systems for robotics or advanced automation systems, 1984.